



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/620,560	07/17/2003	Ming-Chi Liaw	MERCK-1923D1	9252
23599 7590 02/22/2008 MILLEN, WHITE, ZELANO & BRANIGAN, P.C. 2200 CLARENDON BLVD. SUITE 1400 ARLINGTON, VA 22201				
EXAMINER				
OLSEN, ALLAN W				
ART UNIT		PAPER NUMBER		
1792				
MAIL DATE		DELIVERY MODE		
02/22/2008		PAPER		

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.



UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents  
United States Patent and Trademark Office  
P.O. Box 1450  
Alexandria, VA 22313-1450  
[www.uspto.gov](http://www.uspto.gov)

**BEFORE THE BOARD OF PATENT APPEALS  
AND INTERFERENCES**

Application Number: 10/620,560  
Filing Date: July 17, 2003  
Appellant(s): LIAW ET AL.

Anthony Zelano and Jennifer Branigan  
For Appellant

**EXAMINER'S ANSWER**

This is in response to the appeal brief filed September 18, 2007 appealing from the  
Office action mailed November 15, 2006.

**(1) Real Party in Interest**

A statement identifying by name the real party in interest is contained in the brief.

**(2) Related Appeals and Interferences**

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

**(3) Status of Claims**

The statement of the status of claims contained in the brief is correct.

**(4) Status of Amendments After Final**

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

**(5) Summary of Claimed Subject Matter**

The summary of claimed subject matter contained in the brief is correct.

**(6) Grounds of Rejection to be Reviewed on Appeal**

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

**(7) Claims Appendix**

The copy of the appealed claims contained in the Appendix to the brief is correct.

**(8) Evidence Relied Upon**

**(9) Grounds of Rejection**

The following grounds of rejection are applicable to the appealed claims:

**Claim Rejections - 35 USC § 102/103**

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

**Claims 13, 15, 16, 18-20, 24 and 25 are rejected under 35 U.S.C. 102(b) as being anticipated by Ohnishi et al. in EP 0618612A2 (hereinafter, Ohnishi) or, in the alternative, under 35 U.S.C. 103(a) as obvious over Ohnishi.**

Ohnishi teaches a process whereby organic and inorganic sidewall residue is removed from a substrate after the plasma etching of the substrate through a patterned photoresist mask (figure 7a). Ohnishi teaches conducting a 5-10 minute cleaning process while the temperature is maintained between 80° and 130° C (column 8, lines 5-13). As a comparative example, Ohnishi teaches a cleaning solution comprising H<sub>2</sub>SO<sub>4</sub>, H<sub>2</sub>O<sub>2</sub> and HF (column 7, lines 38-41). Additionally, Ohnishi teaches a cleaning solution comprising H<sub>2</sub>SO<sub>4</sub>, H<sub>2</sub>O<sub>2</sub> and an HF generating compound, for example,

Art Unit: 1792

HSO<sub>3</sub>F. Ohnishi teaches compositions wherein the concentration of HSO<sub>3</sub>F ranges from 0.005% to 7.5%. This rejection is made in the 102/103 alternative for several reasons<sup>1</sup>. Except for the comparative example, Ohnishi does not teach adding HF directly to the solution. Rather, Ohnishi teaches providing a compound that generates HF in situ. Ohnishi does not expressly disclose the amount of HF that is produced in the solution. However, like appellant, Ohnishi teaches removing silicon dioxide and photoresist sidewall residue after the dry etching of a semiconductor wafer while not damaging the surface of the wafer. See figures 7(a) and 7(b). In view of the striking similarity between the results obtained from Ohnishi's and appellant's compositions, it is reasonable to conclude that these like results are obtained as a result of using like compositions. This, in part, prompted the rejection to be made in the 102/103 alternative because, "where the Patent Office has reason to believe that a functional limitation asserted to be critical for establishing novelty in the claimed subject matter may, in fact, be an inherent characteristic of the prior art, it possesses the authority to require the [appellant] to prove that the subject matter shown to be in the prior art does not possess the characteristic relied on".<sup>2</sup>

---

<sup>1</sup> Example of circumstances when an alternative 102/103 rejection is appropriate:

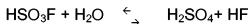
- a. When the reference discloses all the limitations of a claim except a property or function, and the examiner cannot determine whether or not the reference inherently possesses properties which anticipate or render obvious the claimed invention but has basis for shifting the burden of proof to applicant as in *In re Fitzgerald*, 619 F.2d 67, 205 USPQ 594 (CCPA 1980). See MPEP §§ 2112- 2112.02.
- b. When the interpretation of the claims is or may be in dispute, i.e., given one interpretation, a rejection under 35 U.S.C. 102 is appropriate and given another interpretation, a rejection under 35 U.S.C. 103(a) is appropriate.
- c. When the ranges disclosed in the reference and claimed by applicant overlap in scope but the reference does not contain a specific example within the claimed range. See the concurring opinion in *Ex parte Lee*, 31 USPQ2d 1105 (Bd. Pat. App. & Inter. 1993). See MPEP § 2131.03.

<sup>2</sup> *In re Best*, 562 F.2d 1252, 1255, 195 USPQ 430, 433-34 (CCPA 1977) at 1254-55, 195 USPQ at 433 (quoting from *In re Swinehart*, 58 CCPA 1027, 439 F.2d 210, 169 USPQ 226 (1971)).

The examiner notes that Ohnishi discloses providing fluorosulfonic acid,  $\text{HSO}_3\text{F}$ , to the composition in lieu of providing HF, while appellant's claims are directed to a composition "consisting essentially of" three components:

- a) sulfuric acid;
- b) hydrogen fluoride, ammonium fluoride or an alkali metal fluoride; and,
- c) hydrogen peroxide.

To the extent that Ohnishi's  $\text{HSO}_3\text{F}$  embodiments even need to be relied upon, the examiner notes that Ohnishi discloses the following dynamic solution reactions:



As such, Ohnishi's inclusion of  $\text{HSO}_3\text{F}$  is not at odds with the "consisting essentially of" language because the above reaction dynamic reveals that appellant's composition, said to "consist essentially of"  $\text{H}_2\text{O}_2$ ,  $\text{H}_2\text{SO}_4$  and HF, actually contains the very same fluorosulfonic acid component that is provided by Ohnishi. Because,  $\text{HSO}_3\text{F}$  is an inevitable component of appellant's compositions, the "consisting essentially of" claim language cannot be viewed as being exclusive of  $\text{HSO}_3\text{F}$ .

---

Most significant, however, is Ohnishi's disclosed comparative example of "a solution formed by adding 1% hydrofluoric acid to a liquid mixture with a 5:1 ratio of sulfuric acid: hydrogen peroxide" (column 7, lines 38-41). Ohnishi's comparative example reads on the broadly recited  $\text{H}_2\text{SO}_4$ : HF ratio of 10:1 to 700:1 by weight, regardless of the interpretation one gives to Ohnishi's recitation of, "a solution formed by adding 1% hydrofluoric acid to a liquid mixture with a 5:1 ratio of sulfuric acid: hydrogen peroxide". Detailed calculations for various interpretations are included in the calculations appendix. These calculations indicate a  $\text{H}_2\text{SO}_4$ : HF weight ratio ranging from about 75:1 to about 300:1. As such, Ohnishi's comparative example anticipates the  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$  ratio recited in claim 13. It is additionally noted that appendix calculation a3) that shows a  $\text{H}_2\text{SO}_4$ : HF weight ratio of 225:1 also leads to a 3: 1 volume ratio between ( $\text{H}_2\text{SO}_4$  + HF) and  $\text{H}_2\text{O}_2$ .

### ***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

**Claims 14, 17, 21, and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ohnishi.**

The above noted teachings of Ohnishi are herein relied upon.

Ohnishi does not teach:

1. the type of photoresist resist as being one of a g-line, i-line, Deep-UV, e-beam or X-ray;
2. removing photoresist while the operation pressure is maintained at 1 atm;
3. a  $(\text{H}_2\text{SO}_4 + \text{HF})$ :  $\text{H}_2\text{O}_2$  ratio of 3:1.

It would have been obvious to one skilled in the art to apply the method of Ohnishi to one of a g-line, i-line, Deep-UV, e-beam or X-ray photoresist because Ohnishi is directed to the removal of a generic photoresist and the types of photoresist recited in claim 14 include the most common types of photoresist that were in use at the time of Ohnishi's disclosure.

It would have been obvious to one skilled in the art to carry out the method of Ohnishi while maintaining a pressure of 1 atm because when a reference is completely silent on a parameter such as pressure, the skilled artisan would assume that the ambient pressure is used. If Ohnishi intended the method to be carried out at anything other than 1 atm, one would expect this to be disclosed. In the absence of such a discloser it would be obvious to operate at a pressure of 1 atm.

It would have been obvious to one skilled in the art to optimize the process with regard to the ratio of the components in the cleaning solution because Ohnishi teaches that the composition ratio is a cause-effective variable.



Art Unit: 1792

"Normally, it is to be expected that a change in temperature, or in concentration, or in both, would be an unpatentable modification. Under some circumstances, however, changes such as these may impart patentability to a process if the particular ranges claimed produce a new and unexpected result which is different in kind and not merely degree from the results of the prior art... such ranges are termed "critical ranges and the applicant has the burden of proving such criticality... More particularly, where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation."<sup>3</sup>

Additionally, absent a showing of criticality<sup>4</sup>, such concentration limitations are considered obvious.

### **(10) Response to Argument**

Appellant asserts, claims 13, 15, 16, 18-20, 24 and 25 are not: (a) anticipated by Ohnishi or in the alternative, (b) are not obvious to one of ordinary skill in the art over Ohnishi.

Regarding the teaching of Ohnishi, as it relates to anticipation, appellant challenges the examiner's assertion that "similar results are obtained from Ohnishi's and [appellant's] compositions". Appellant calls attention to figure 3 of Ohnishi to argue:

*"[t]he etching results for HF and HSO<sub>3</sub>F ("fluorosulfuric acid") are not the same. They do not etch in the same manner."*

Additionally, appellant notes:

---

<sup>3</sup> *In re Aller* 105 USPQ 233, 255 (CCPA 1955). See also *In re Waite* 77 USPQ 586 (CCPA 1948); *In re Scherl* 70 USPQ 204 (CCPA 1946); *In re Irmischer* 66 USPQ 314 (CCPA 1945); *In re Norman* 66 USPQ 308 (CCPA 1945); *In re Swenson* 56 USPQ 372 (CCPA 1942); *In re Sola* 25 USPQ 433 (CCPA 1935); *In re Dreyfus* 24 USPQ 52 (CCPA 1934).

<sup>4</sup> *Akzo v. E.I. du Pont de Nemours* 1 USPQ 2d 1704 (Fed. Cir. 1987)

Art Unit: 1792

*"Ohnishi does not teach the amount of HF that is produced in solution and ... the amount of HF generated cannot be determined."*

Furthermore, regarding the  $\text{HSO}_3\text{F} + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{SO}_4 + \text{HF}$  reaction dynamic

(referred to, by the examiner in the final Office action, by the commonly used term,

"equilibrium"), appellant states:

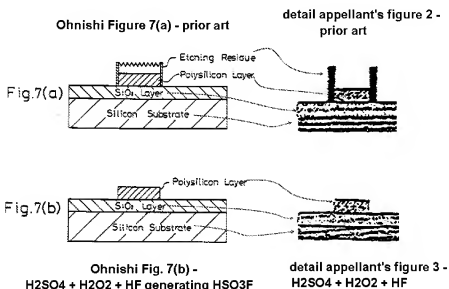
*"if the HF+ H<sub>2</sub>SO<sub>4</sub> were in equilibrium with HSO<sub>3</sub>F + H<sub>2</sub>O, the curves would be identical or at least parallel (due to differences in concentrations). As clearly depicted, this is not the case. Equilibrium is not reached and, thus, there is a difference between starting with HF and starting with HSO<sub>3</sub>F. One skilled in the art could not conclude that a sufficiently high HF concentration could be reached when starting from HSO<sub>3</sub>F."*

In response, the examiner notes the following:

- Figure 3, upon which appellant relies, depicts data for the "solution formed by adding 1% hydrofluoric acid to a liquid mixture with a 5:1 ratio of sulfuric acid: hydrogen peroxide". As noted in the above rejection, this is a composition that outright anticipates appellant's claim 13 without reliance on Ohnishi's fluorosulfonic acid embodiments.
- To the extent that it matters, figure 3 depicts as much similarity between HF and HSO<sub>3</sub>F as it depicts differences. It is essential to realize that the line representing the HSO<sub>3</sub>F data is generated from only two data points. At time = 0, the data points for HSO<sub>3</sub>F and HF differ. However, at time = 1 hour, the two points have converged, that is to say the etching result for HSO<sub>3</sub>F is identical to the result from HF at the 1 hour mark. Furthermore, the extrapolation of the HSO<sub>3</sub>F line beyond the 1 hour time marker represents pure (and dubious) speculation. Given the above noted  $\text{HSO}_3\text{F} + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{SO}_4 + \text{HF}$  reaction dynamic, it is reasonable to expect an extrapolated HSO<sub>3</sub>F line to tail off and become coincident with the HF line. As shown at the 1 hour mark, and as stated by appellant, *if the HF+ H<sub>2</sub>SO<sub>4</sub> were in equilibrium with HSO<sub>3</sub>F + H<sub>2</sub>O, the curves would be identical or at least parallel*.

Art Unit: 1792

- Regarding the examiner's contention that appellant and Ohnishi achieve comparable results, the examiner notes the following:
  - as shown below, figures 7(a) and 7(b) of Ohnishi depict the same advantage over the prior art that appellant's show in their figures 2 and 3.

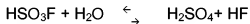


- Ohnishi teaches a 10 minute cleaning treatment at a temperature of preferably between 80° and 130°C to remove etching residue from a semiconductor wafer without damaging the wafer's surface, whereas appellant claims a 10 minute cleaning treatment and a temperature of between 0° and 130°C, or between 120° and 140°C, to remove etching residue from a semiconductor wafer without etching the wafer at rate greater than or equal to 1 Å/min (i.e., "without damaging the wafer's surface").

Appellant next addresses the examiner's reliance on *In re Best* to require appellant to prove that the subject matter shown to be in the prior art does not possess the characteristic relied upon. Appellant argues, that before that PTO can impose such a requirement, the PTO must show that it is reasonable to believe that the prior art does indeed possess the characteristic relied upon.

Again, the examiner relies upon the following facts to show that it is reasonable to believe that Ohnishi does indeed possess the claimed  $\text{H}_2\text{SO}_4$ : HF ratio:

1. Ohnishi obtains results that are strikingly similar to applicant's results
2. Ohnishi's results are obtained from a solution "consisting of"  $\text{H}_2\text{SO}_4$ ,  $\text{H}_2\text{O}_2$  and  $\text{HSO}_3\text{F}$ .
3. Ohnishi provides  $\text{HSO}_3\text{F}$  to generate HF via the following:



4. After 1 hour,  $\text{HSO}_3\text{F}$  results = HF results

Appellant argues the examiner is unjustified in concluding that Ohnishi's solution, formed by adding 1% hydrofluoric acid to a liquid mixture with a 5:1 ratio of sulfuric acid : hydrogen peroxide, corresponds to a 300:1  $\text{H}_2\text{SO}_4$  :HF ratio because "the teachings of Ohnishi are so ambiguous". Appellant argues:

*"[i]n order to determine if the comparative example satisfies the ratio of a:b in the claims, one would first have to know if the reference is teaching 1% of a standard 49% HF solution, a 1% HF solution or a 1% concentration of HF in the final solution. It cannot be determined whether the components of Ohnishi's solution are weight, volume or mole amounts."*

Lastly, appellant argues:

*"there is no way to know the ratio of HF to H<sub>2</sub>SO<sub>4</sub>. Without knowing how much of the 1% HF solution was added to the H<sub>2</sub>SO<sub>4</sub>:H<sub>2</sub>O<sub>2</sub> mixture it is impossible to know the final amount of HF in Ohnishi's comparative example. Ohnishi is not only ambiguous with regards to weight, volume or mole percentage ratios but is ambiguous with regards to the amount of 1%HF solution that was added to the H<sub>2</sub>SO<sub>4</sub>:H<sub>2</sub>O<sub>2</sub> mixture."*

The examiner notes that this last argument is based upon the notion that Ohnishi is adding an unknown volume of a 1% solution of HF to the H<sub>2</sub>SO<sub>4</sub>/H<sub>2</sub>O<sub>2</sub> mixture. In so doing, appellant has selected the one interpretation of Ohnishi that inevitably suggests Ohnishi's disclosure is inadequate. Alternatively, one can interpret Ohnishi's "adding 1% hydrofluoric acid to a liquid mixture" to mean the final solution will have an HF concentration of 1%. By this reading, Ohnishi does provide a sufficient disclosure to replicate the solutions – regardless of whether one uses weight, volume or mole ratios. As patent documents are generally required to enable one skilled in the art to replicate the disclosed invention, it is reasonable to select the interpretation of Ohnishi that enables the process. Stated a little differently, when the prior art can be interpreted in two ways, with one interpretation being enabling while the other is not, it would be obvious for one skilled in the art to adopt the enabling interpretation because that is the only choice that would allow the skilled artisan to proceed.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

/Allan Olsen/  
Primary Examiner, Art Unit 1792

Conferees: /Parviz Hassanzadeh/  
SPE, AU 1792

/Romulo Delmendo/  
Romulo Delmendo

Art Unit: 1792

## Appendix: Calculations

Standard Concentrations of concentrated solutions (weight percent): $\text{H}_2\text{SO}_4 = 96\%$     $\text{H}_2\text{O}_2 = 30\%$     $\text{HF} = 49\%$ Densities: $\text{H}_2\text{SO}_4 = 1.84 \text{ g/ml}$ ;  $\text{HF} = 1.16 \text{ g/ml}$ ;  $\text{H}_2\text{O}_2 = 1.13 \text{ g/ml}$ Density of 5:1  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2 = 1.72 \text{ g/ml}$  (weighted average)

---

**1% HF in 5:1  $\text{H}_2\text{SO}_4$  :  $\text{H}_2\text{O}_2$** 

Calculations follow for each of:

## A) Volume percent of concentrated HF solution

- a1) 1% by volume of concentrated HF in solution that is 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- a2) 1% by volume of concentrated HF in solution that is 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- a3) 1% by volume of concentrated HF in solution with a 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

## B) Weight percent of concentrated HF solution

weight/weight (w/w) (e.g., 1g solute/100 g solution)

weight/volume (w/v) (e.g., 1g solute/100 ml solution)

- b1) 1% concentrated HF (w/w) in a solution that is 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- b2) 1% concentrated HF (w/w) in a solution that is 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- b3) 1% concentrated HF (w/w) in a solution with a 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- b4) 1% concentrated HF (w/v) in solution that is 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- b5) 1% concentrated HF (w/v) in solution that is 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- b6) 1% concentrated HF (w/v) in solution with a 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

## C) Weight percent of hydrogen fluoride molecule (rather than the aqueous acid solution)

- c1) 1% HF (w/w) in a solution that is 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- c2) 1% HF (w/w) in a solution that is 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- c3) 1% HF (w/w) in a solution with a 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- c4) 1% HF (w/v) in a solution that is 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- c5) 1% HF (w/v) in a solution that is 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$
- c6) 1% HF (w/v) in a solution with a 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

Art Unit: 1792

A) Volume percent of concentrated HF solution

a1) 1% by volume of concentrated HF in solution that is 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 1 ml of 49% HF + 99 ml of 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 99 ml of 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$  = 82.5 ml  $\text{H}_2\text{SO}_4$  + 16.5 ml  $\text{H}_2\text{O}_2$ 1 ml HF + 82.5 ml  $\text{H}_2\text{SO}_4$  + 16.5 ml  $\text{H}_2\text{O}_2$ 

1 ml of 49% HF \* (1.16 g/ml) = 1.16 g of 49% HF

49% of 1.16 g = **0.57 g HF**82.5 ml  $\text{H}_2\text{SO}_4$  \* (1.84 g/ml) = 152g of 96%  $\text{H}_2\text{SO}_4$  = **146 g  $\text{H}_2\text{SO}_4$** 146g  $\text{H}_2\text{SO}_4$ : 0.57 g HF $\text{H}_2\text{SO}_4$ : HF**256: 1** weight ratio reads on claim 1.

Art Unit: 1792

a2) 1% by volume of concentrated HF in solution that is 5:1 by weight  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

1ml of 49% HF in 99 ml of 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

99 ml of 5:1 w/w of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$  \* (1.72 g/ml) = 170.28 g of 5:1 by weight  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

$170.28 * (5/6) = 142 \text{ g } \text{H}_2\text{SO}_4$  of 96%  $\text{H}_2\text{SO}_4 = 136 \text{ g } \text{H}_2\text{SO}_4$

1 ml of 49% HF \* (1.16 g/ml) = 1.16 g of 49% HF

49% of 1.16 g = **0.57 g HF**

136 g  $\text{H}_2\text{SO}_4$ : 0.57 g HF

239  $\text{H}_2\text{SO}_4$ : 1 HF weight ratio

$\text{H}_2\text{SO}_4$ : HF

**239: 1** weight ratio reads on claim 1.



Art Unit: 1792

a3) 1% by volume of concentrated HF in solution with 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 1 ml of 49% HF \* in 99 ml of 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$99 \text{ ml} = (72.5 \text{ ml } \text{H}_2\text{SO}_4 + 26.5 \text{ ml } \text{H}_2\text{O}_2)^*$$

(\* see calculation regarding claim 21 below)

To verify the 5:1 molar ratio,

$$72.5 \text{ ml } \text{H}_2\text{SO}_4 (1.84 \text{ g/ml}) = 133.4 \text{ g of } 96\% \text{ } \text{H}_2\text{SO}_4 = \mathbf{128 \text{ g } \text{H}_2\text{SO}_4}$$

$$128 \text{ g } \text{H}_2\text{SO}_4 (1 \text{ mol}/98 \text{ g}) = 1.31 \text{ mol } \text{H}_2\text{SO}_4$$

$$26.5 \text{ ml } \text{H}_2\text{O}_2 (1.1 \text{ g/ml}) = 29.2 \text{ g of } 30\% \text{ } \text{H}_2\text{O}_2 = 8.75 \text{ g } \text{H}_2\text{O}_2$$

$$8.75 \text{ g } \text{H}_2\text{O}_2 (1 \text{ mol}/34 \text{ g}) = 0.257 \text{ mol } \text{H}_2\text{O}_2$$

$$1.31 \text{ mol } \text{H}_2\text{SO}_4 : 0.257 \text{ mol } \text{H}_2\text{O}_2 = 5 \text{ moles } \text{H}_2\text{SO}_4 : 1 \text{ mole } \text{H}_2\text{O}_2$$

$$1 \text{ ml } 49\% \text{ HF} * (1.16 \text{ g/ml}) = 1.16 \text{ g of } 49\% \text{ HF} = \mathbf{0.57 \text{ g HF}}$$

$$128 \text{ g } \text{H}_2\text{SO}_4 : 0.57 \text{ g HF}$$

**225: 1** weight ratio reads on claim 1.\* Regarding Claim 21:

$$(1 \text{ ml HF} + 72.5 \text{ ml } \text{H}_2\text{SO}_4) : 26.5 \text{ ml } \text{H}_2\text{O}_2$$

$$73.5/26.5 : 26.5/26.5 = 2.8 : 1 \sim \mathbf{3 : 1}$$

Art Unit: 1792

## B) Weight percent of Concentrated HF

b1) 1% w/w of 49% HF in a 5:1 by volume  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 1% (w/w) of 49% HF = 1 g 49% HF in 99 g of 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 99 g of 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$  (1 ml/1.72 g) = 57.7 ml of 5:1  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 5/6 of a 5:1  $\text{H}_2\text{SO}_4$ : $\text{H}_2\text{O}_2$  solution is  $\text{H}_2\text{SO}_4$ , so,(5/6)\* 57.7 ml of 5:1 by volume  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$  = 48.1 ml  $\text{H}_2\text{SO}_4$  of 96%  $\text{H}_2\text{SO}_4$ 48.1 ml (1.84 g/ml) = 86.5 g 96 %  $\text{H}_2\text{SO}_4$  = **83.0 g  $\text{H}_2\text{SO}_4$** 1 g of 49% HF = **.49 g of HF**83.0 g  $\text{H}_2\text{SO}_4$ : .49 g HF $\text{H}_2\text{SO}_4$ : HF**169.5: 1** weight ratio reads on claim 1.

Art Unit: 1792

b2) 1% w/w of concentrated HF in solution that is 5:1 by weight  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 1 g of 49% HF in 99 g of 5:1 by weight  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 99 g of 5:1 w/w of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$  $(5/6) * 99 \text{ g of } 5:1 \text{ w/w of } \text{H}_2\text{SO}_4 : \text{H}_2\text{O}_2 = 82.5 \text{ g } \text{H}_2\text{SO}_4 \text{ of } 96\% \text{ H}_2\text{SO}_4 = \mathbf{79.2 \text{ g } H_2SO_4}$ 1 g of 49% HF = **.49 g HF**79.2 g  $\text{H}_2\text{SO}_4$  : 0.49 g HF162  $\text{H}_2\text{SO}_4$  : 1 HF weight ratio $\text{H}_2\text{SO}_4$ : HF**162: 1** weight ratio reads on claim 1.

Art Unit: 1792

b3) 1% (w/w) of concentrated HF in solution with 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 1g of 49% HF in 99 g of 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$  $81 \text{ g } \text{H}_2\text{SO}_4 + 18 \text{ g } \text{H}_2\text{O}_2 = 99 \text{ g}$  with 5:1 molar ratio.To verify the 5:1 molar ratio between  $\text{H}_2\text{SO}_4$  and  $\text{H}_2\text{O}_2$  $81 \text{ g of } 96\% \text{ } \text{H}_2\text{SO}_4 = 77.8 \text{ g } \text{H}_2\text{SO}_4 * (1 \text{ mol}/98 \text{ g}) = .793 \text{ mol } \text{H}_2\text{SO}_4$  $18 \text{ g of } 30\% \text{ } \text{H}_2\text{O}_2 = 5.4 \text{ g } \text{H}_2\text{O}_2 * (1 \text{ mol}/34 \text{ g}) = .159 \text{ mol } \text{H}_2\text{O}_2$  $.793 \text{ mol } \text{H}_2\text{SO}_4$ :  $.159 \text{ mol } \text{H}_2\text{O}_2$ 

5:1

81 g of 96%  $\text{H}_2\text{SO}_4$ : 1g of 49% HF77.8 g  $\text{H}_2\text{SO}_4$ : 0.49 g HF $\text{H}_2\text{SO}_4$ : HF**159: 1** weight ratio reads on claim 1.

Art Unit: 1792

b4) 1% (w/v) of 49% HF in a 5:1 by volume  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

$$1\% \text{ (w/v)} = 1 \text{ g solute}/100 \text{ ml solution}$$

$$1 \text{ g } 49\% \text{ HF (1ml/1.16 g)} = .86 \text{ ml}$$

Therefore, need 99.14 ml of 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

$$99.15 \text{ ml of 5:1 by volume of } \text{H}_2\text{SO}_4\text{: } \text{H}_2\text{O}_2 * (5/6) = 82.6 \text{ ml } \text{H}_2\text{SO}_4$$

$$82.6 \text{ ml (1.84 g/ml)} = 152 \text{ g } 96\% \text{ } \text{H}_2\text{SO}_4 = \mathbf{146 \text{ g } \text{H}_2\text{SO}_4}$$

$$1 \text{ g of } 49\% \text{ HF} = \mathbf{.49 \text{ g of HF}}$$

$$146 \text{ g } \text{H}_2\text{SO}_4\text{: } .49 \text{ g HF}$$

$$\text{H}_2\text{SO}_4\text{: HF}$$

**298: 1** weight ratio reads on claim 1.

Art Unit: 1792

b5) 1% w/v of concentrated HF in solution that is 5:1 by weight  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$1\% \text{ w/v} = 1 \text{ g solute} / 100 \text{ ml solution}$$

$$1 \text{ g } 49\% \text{ HF (1ml/1.16 g)} = .86 \text{ ml}$$

Therefore, need 99.14 ml of 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$99.14 \text{ ml} * (1.72 \text{ g/ml}) = 170 \text{ g}$$

$$170 \text{ g} * (5/6) = 142 \text{ g of } 96\% \text{ } \text{H}_2\text{SO}_4 = \mathbf{136 \text{ g } \text{H}_2\text{SO}_4}$$

$$1 \text{ g of } 49\% \text{ HF} = \mathbf{.49 \text{ g HF}}$$

$$136 \text{ g } \text{H}_2\text{SO}_4 : 0.49 \text{ g HF}$$

$$\text{H}_2\text{SO}_4 : \text{HF}$$

**278: 1** weight ratio reads on claim 1.

Art Unit: 1792

b6) 1% (w/v) of concentrated HF in solution with 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$1\% \text{ w/v} = 1 \text{ g solute /100 ml solution}$$

$$1 \text{ g } 49\% \text{ HF (1ml/1.16 g)} = .86 \text{ ml}$$

Therefore, need 99.14 ml of 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$99.14 \text{ ml} = 72.5 \text{ ml } \text{H}_2\text{SO}_4 + 26.6 \text{ ml } \text{H}_2\text{O}_2$$

To verify the 5:1 mole ratio,

$$72.5 \text{ ml } \text{H}_2\text{SO}_4 (1.84 \text{ g/ml}) = 133.4 \text{ g of } 96\% \text{ } \text{H}_2\text{SO}_4 = 128 \text{ g } \text{H}_2\text{SO}_4$$

$$128 \text{ g } \text{H}_2\text{SO}_4 (1 \text{ mol/98 g}) = 1.31 \text{ mol } \text{H}_2\text{SO}_4$$

$$26.6 \text{ ml } \text{H}_2\text{O}_2 (1.1 \text{ g/ml}) = 29.2 \text{ g of } 30\% \text{ } \text{H}_2\text{O}_2 = 8.78 \text{ g } \text{H}_2\text{O}_2$$

$$8.78 \text{ g } \text{H}_2\text{O}_2 (1 \text{ mol/34 g}) = 0.258 \text{ mol } \text{H}_2\text{O}_2$$

$$1.31 \text{ mol } \text{H}_2\text{SO}_4: 0.258 \text{ mol } \text{H}_2\text{O}_2$$

$$5 \text{ moles } \text{H}_2\text{SO}_4: 1 \text{ mole } \text{H}_2\text{O}_2$$

$$1\text{g of } 49\% \text{ HF} = \mathbf{0.49 \text{ g HF}}$$

$$128 \text{ g } \text{H}_2\text{SO}_4: 0.49 \text{ g HF}$$

$$\text{H}_2\text{SO}_4: \text{HF}$$

**261:1** weight ratio reads on claim 1.

Art Unit: 1792

C) Weight percent of hydrogen fluoride molecule (rather than of the aqueous solution)

c1) 1% HF (w/w) in a solution that is 5:1 by volume of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$1\% \text{ HF (w/w)} = 1\text{ g HF} / 100 \text{ g of solution}$$

$$1 \text{ g HF} = 2 \text{ g of } 49\% \text{ HF}$$

$$98 \text{ g of } 5:1 \text{ by volume of } \text{H}_2\text{SO}_4: \text{H}_2\text{O}_2$$

$$98 \text{ g} * (1 \text{ ml} / 1.72 \text{ g}) = 56.98 \text{ ml}$$

$$(5/6) * 56.98 = 47.48 \text{ ml } \text{H}_2\text{SO}_4$$

$$47.48 \text{ ml } \text{H}_2\text{SO}_4 * (1.84 \text{ g/ml}) = 87.36 \text{ g } \text{H}_2\text{SO}_4$$

$$\text{H}_2\text{SO}_4: \text{HF}$$

**87: 1** weight ratio reads on claim 1.



Art Unit: 1792

c2) 1% HF (w/w) in a solution that is 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

$$1\% \text{ HF (w/w)} = 1 \text{ g HF} / 100 \text{ g of solution}$$

$$1 \text{ g HF} = 2 \text{ g of } 49\% \text{ HF}$$

98 g of 5:1 by weight of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$

$$(5/6) * 98 \text{ g} = \mathbf{81.67 \text{ g } H_2SO_4}$$

$$81.7 \text{ g } H_2SO_4: 1 \text{ g HF}$$

$$H_2SO_4: HF$$

**82: 1** weight ratio reads on claim 1.

Art Unit: 1792

c3) 1% HF (w/w) in a solution with a 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

1% (w/w) HF = 1g HF in 100 g of solution

**1g HF** = 2g of 49% HF98 g of 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 80.2 g of  $\text{H}_2\text{SO}_4$  + 17.8 g  $\text{H}_2\text{O}_2$  = 98 g of 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

To verify the 5:1 molar ratio,

80.2 g of 96%  $\text{H}_2\text{SO}_4$  = **77.0 g  $\text{H}_2\text{SO}_4$** 77.0 g  $\text{H}_2\text{SO}_4$  \* (1 mol/98 g) = 0.786 moles of  $\text{H}_2\text{SO}_4$ 17.8 g of 30%  $\text{H}_2\text{O}_2$  = 5.34 g  $\text{H}_2\text{O}_2$ 5.34 g  $\text{H}_2\text{O}_2$  \* (1 mol/34 g) = 0.157 moles of  $\text{H}_2\text{O}_2$ 0.786 moles of  $\text{H}_2\text{SO}_4$ : 0.157 moles of  $\text{H}_2\text{O}_2$  = 5: 1 mole ratio**77g  $\text{H}_2\text{SO}_4$ : 1 g HF** $\text{H}_2\text{SO}_4$ : HF**77: 1** weight ratio reads on claim 1.

Art Unit: 1792

c4) 1% (w/v) of hydrogen fluoride in a 5:1 by volume  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$1\% \text{ (w/v)} = 1 \text{ g solute}/100 \text{ ml solution}$$

$$1 \text{ g HF} = 2 \text{ g of } 49\% \text{ HF}$$

$$2 \text{ g of } 49\% \text{ HF} * (1 \text{ ml}/1.16 \text{ g}) = 1.72 \text{ ml of } 49\% \text{ HF}$$

$$1.72 \text{ ml of } 49\% \text{ HF} + 98.28 \text{ ml of } 5:1 \text{ by volume } \text{H}_2\text{SO}_4: \text{H}_2\text{O}_2 = 100 \text{ ml total solution}$$

$$98.28 \text{ ml of } 5:1 \text{ by volume } \text{H}_2\text{SO}_4: \text{H}_2\text{O}_2$$

$$(5/6) * 98.28 \text{ ml of } 5:1 \text{ by volume } \text{H}_2\text{SO}_4: \text{H}_2\text{O}_2 = 81.9 \text{ ml of } 96\% \text{ H}_2\text{SO}_4$$

$$81.9 \text{ ml} * (1.84 \text{ g/ml}) = 150.7 \text{ g } 96\% \text{ H}_2\text{SO}_4$$

$$150.7 \text{ g of } 96\% \text{ H}_2\text{SO}_4 = \mathbf{144.7 \text{ g H}_2\text{SO}_4}$$

$$145 \text{ g H}_2\text{SO}_4: 1 \text{ g HF}$$

$$\text{H}_2\text{SO}_4: \text{HF}$$

**145: 1** weight ratio reads on claim 1.

Art Unit: 1792

c5) 1% w/v of hydrogen fluoride in solution that is 5:1 by weight  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$1\% \text{ (w/v)} = 1 \text{ g solute/100 ml solution)}$$

$$1 \text{ g HF} = 2 \text{ g of 49\% HF}$$

$$2 \text{ g of 49\% HF} * (1 \text{ ml/1.16 g}) = \underline{1.72 \text{ ml of 49\% HF}}$$

1.72 ml of 49 % HF + 98.28 ml of 5:1 by weight  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$  = 100 ml total solution

$$98.28 \text{ ml of 5:1 by weight } \text{H}_2\text{SO}_4\text{: } \text{H}_2\text{O}_2$$

$$98.28 \text{ ml} * (1 \text{ .72 g/ml}) = 169 \text{ g of 5:1 by weight } \text{H}_2\text{SO}_4\text{: } \text{H}_2\text{O}_2$$

$$169 \text{ g} * (5/6) = 140.9 \text{ g of 96 \% } \text{H}_2\text{SO}_4 = \mathbf{135 \text{ g } \text{H}_2\text{SO}_4}$$

$$135 \text{ g } \text{H}_2\text{SO}_4 : 1 \text{ g HF}$$

$$\text{H}_2\text{SO}_4\text{: HF}$$

**135: 1** weight ratio reads on claim 1.

Art Unit: 1792

c6) 1% (w/v) of concentrated HF in solution with 5:1 mole ratio of  $\text{H}_2\text{SO}_4$ :  $\text{H}_2\text{O}_2$ 

$$1\% \text{ w/v} = 1 \text{ g solute} / 100 \text{ ml solution}$$

$$1 \text{ g HF} = 2 \text{ g of } 49\% \text{ HF}$$

$$2 \text{ g of } 49\% \text{ HF} * (1 \text{ ml}/1.16 \text{ g}) = 1.72 \text{ ml of } 49\% \text{ HF}$$

$$1.72 \text{ ml of } 49\% \text{ HF} + 98.28 \text{ ml of } 5:1 \text{ H}_2\text{SO}_4: \text{H}_2\text{O}_2 \text{ mole ratio} = 100 \text{ ml total solution}$$

$$71.66 \text{ ml of } 96\% \text{ H}_2\text{SO}_4 + 26.62 \text{ ml of } 30\% \text{ H}_2\text{O}_2 = 98.28 \text{ ml with } 5:1 \text{ molar ratio}$$

To verify the 5:1 mole ratio,

$$71.66 \text{ ml H}_2\text{SO}_4 (1.84 \text{ g/ml}) = 131.9 \text{ g of } 96\% \text{ H}_2\text{SO}_4 = 126.6 \text{ g H}_2\text{SO}_4$$

$$126.6 \text{ g H}_2\text{SO}_4 (1 \text{ mol}/98 \text{ g}) = 1.29 \text{ mol H}_2\text{SO}_4$$

$$26.62 \text{ ml H}_2\text{O}_2 (1.1 \text{ g/ml}) = 29.3 \text{ g of } 30\% \text{ H}_2\text{O}_2 = 8.78 \text{ g H}_2\text{O}_2$$

$$8.78 \text{ g H}_2\text{O}_2 (1 \text{ mol}/34 \text{ g}) = 0.258 \text{ mol H}_2\text{O}_2$$

$$1.29 \text{ mol H}_2\text{SO}_4: 0.258 \text{ mol H}_2\text{O}_2$$

$$5 \text{ moles H}_2\text{SO}_4: 1 \text{ mole H}_2\text{O}_2$$

$$126.6 \text{ g H}_2\text{SO}_4: 1 \text{ g HF}$$

$$\text{H}_2\text{SO}_4: \text{HF}$$

**127:1** weight ratio reads on claim 1.